1-6 Characteristics

1-6-1 Capacitance

The capacitance of the dielectric portion of the anode aluminum foil can be calculated with the following formula (discussed in 1-1) :

$$Ca = 8.855\times10^{-8}\ \frac{\varepsilon S}{d}\ (\mu F)$$

The cathode foil has a capacitance (Cc) that uses the oxide layer, which formed by the forming voltage or formed naturally during storage (generally 1V or less), as a dielectric. According to the construction of aluminum electrolytic capacitors, Ca and Cc are connected in a series. Therefore, the capacitance can be determined by the following formula:

$$C = \frac{Ca\times Cc}{Ca + Cc}$$

The standard capacitance tolerance is ±20%(M); however, capacitors with a capacitance tolerance of ±10%(K), etc. are also manufactured for special usage. The capacitance of aluminum electrolytic capacitors changes with temperature and frequency of measurement, so the standard has been set to a frequency of 120Hz and temperature of 20°C.

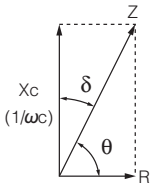
1-6-2 Equivalent Series Resistance (R), Dissipation Facter (tanδ), Impedance (Z)

The equivalent circuit of an aluminum electrolytic capacitor is shown below, The equivalent series resistance is also known as "ESR".

Fig. 1 - 6

C : Capacitance (F)
r : Equivalent parallel resistance of anode oxide film (Ω)
R : Equivalent series resistance (Ω)
L : Equivalent series inductance (H)

A reactance value due to the equivalent series inductance "L" is extremely small at low frequencies (50Hz~1kHz) and can be regarded as zero. Therefore, the following formula can be set up.



$$\tan\delta = \frac{R}{Xc} = \omega CR \qquad \cdots(1-2)$$

$$DF = \tan\delta \times 100\ (\%) \qquad \cdots(1-3)$$

$$PF = \cos\theta = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}} \qquad \cdots(1-4)$$

$$Q = \frac{1}{\tan\delta} = \frac{Xc}{R} \qquad \cdots(1-5)$$

$(\omega = 2\pi f)$

Fig. 1 - 7

The impedance can be expressed by :

$$Z = \frac{1}{j\omega C} + j\omega L + R$$

Its absolute value can be expressed by :

$$|Z| = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$$

Its relation with frequencies is shown by a model curve.

The inductance "L" is mainly from the wound electrode foils and the leads.

ESR "R" is from resistance of the electrode foils, the electrolyte, the leads and each connection.

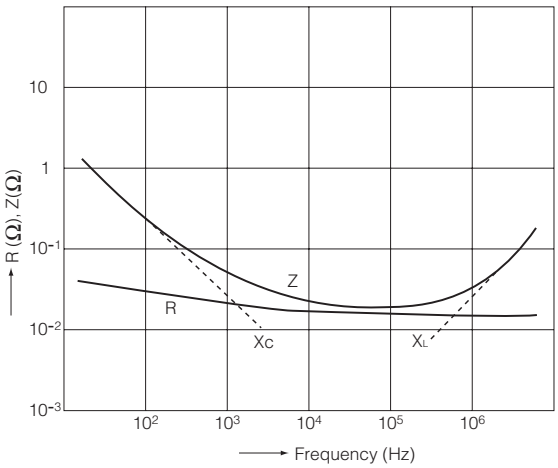


Fig. 1 - 8

1-6-3 Leakage Current

The causes of leakage current in aluminum electrolytic capacitors are listed below :

1)Distorted polarization of dielectric (aluminum oxide layer)
2)Resolution and formation of dielectric
3)Moisture absorption by dielectric
4)Breakdown of dielectric due to the existence of chlorine or iron particles.

The leakage current value can be decreased by proper selection of materials and production methods; however, cannot be totally eliminated.

Leakage current is also dependent upon time, applied voltage and temperature.

The specified leakage current value is measured after the rated voltage of the capacitor is applied at room temperature for a specified time period. When selecting a capacitor for a particular application, characteristics such as temperature dependency, aging stability and etc. must be taken into account.